

TEL-2 Beam-Beam Compensation Studies

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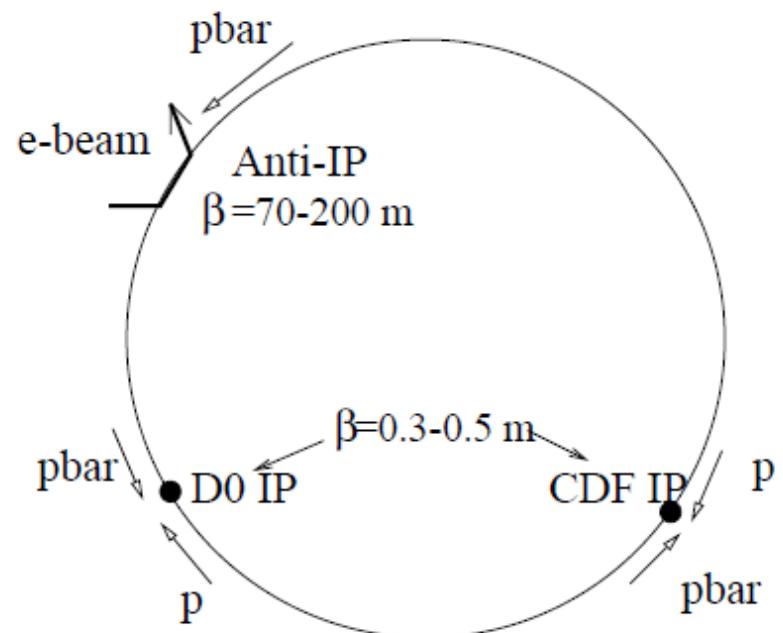
Tevatron Dept. Meeting 4/2/2010

Outline

- Motivation and goals
- TEL-2 improvements
- Recent results
 - Beam alignment
 - Tune shift and tune spread measurement in pbar-only
 - In-store coherent tune measurements
- What's next

Electron Lens for Beam-Beam Compensation

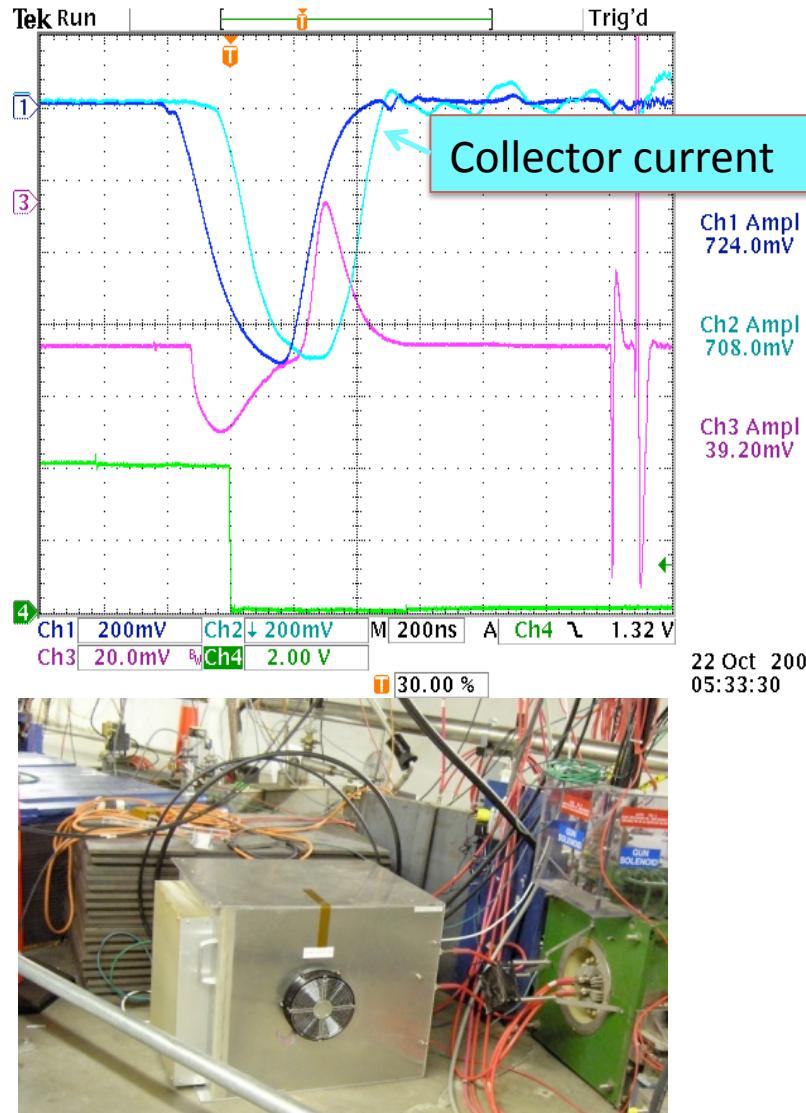
- Space charge compensation in scheme with 4 circulating colliding beams attempted at DCI (G. Arzelia et al., HEACC, 1971)
- Space charge compensation with single-pass electron beam (Electron Lens) proposed for SSC (E. Tsyganov et al., SSCL-PREPRINT-519 ,1993)
- Two ELs at Tevatron, successfully used for LR compensation (V.Shiltsev and D. Finley, FERMILAB-TM-2008, 1997)
- Two ELs under construction for RHIC HO BBC, due 2011 (W.Fischer et al., LBNL-1503E, 2009)
- Possible upgrade scenario for LHC



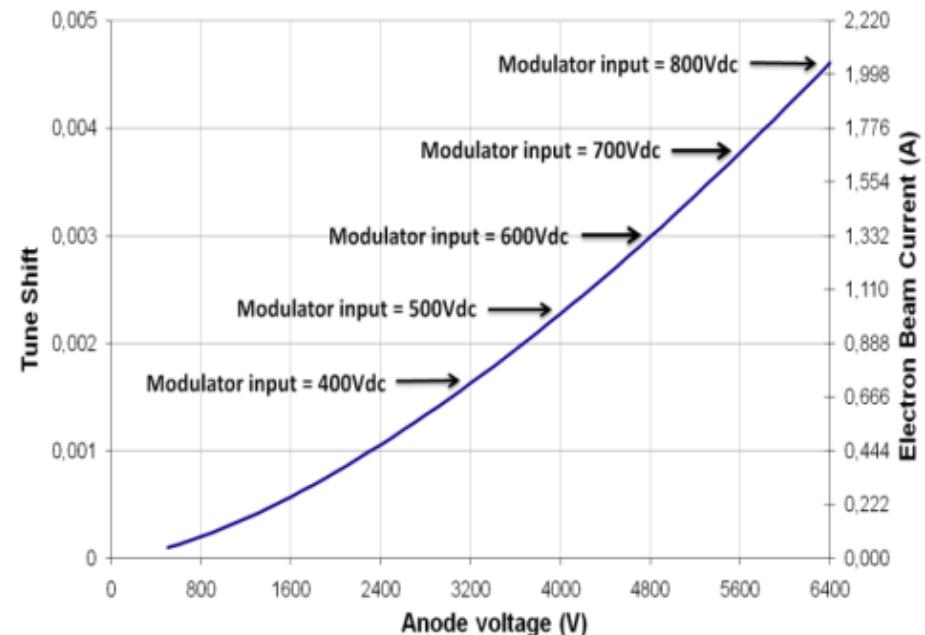
TEL in LARP Beam-Beam Compensation

- Due to large proton/antiproton emittance ratio, pbar head-on beam-beam effects are weak in Tevatron operations
- Goals for Gaussian TEL in FY10 LARP Beam-Beam Task
 - Observe effect of the Gaussian e- beam on proton/pbar tune spread (expect $\delta Q=0.008$ at 1A)
 - Demonstrate that HO BBC does not lead to life time degradation
 - Study effects of various imperfections
 - Provide input for simulations

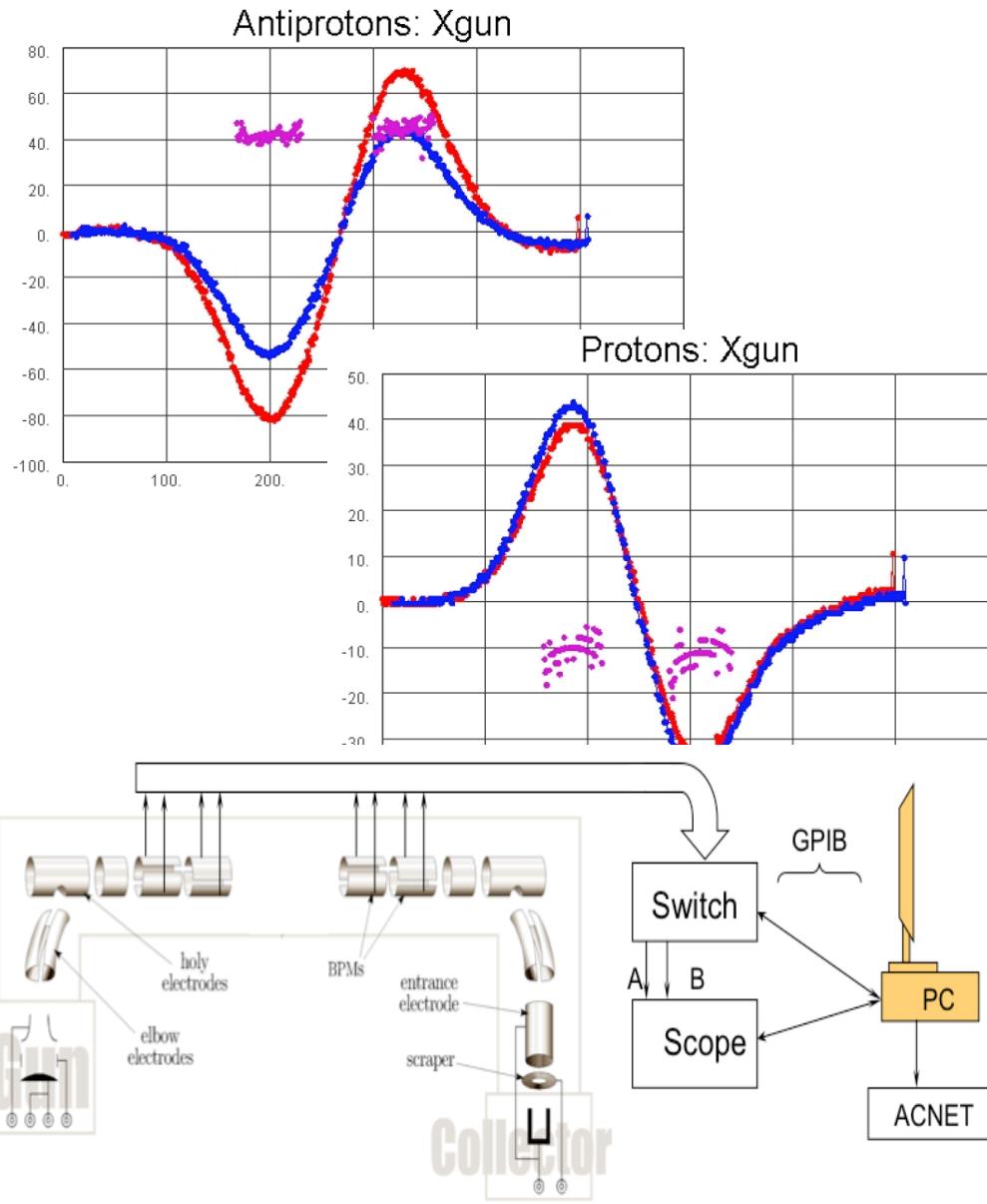
TEL Improvements: Stacked Transformer Modulator (G.Saewert)



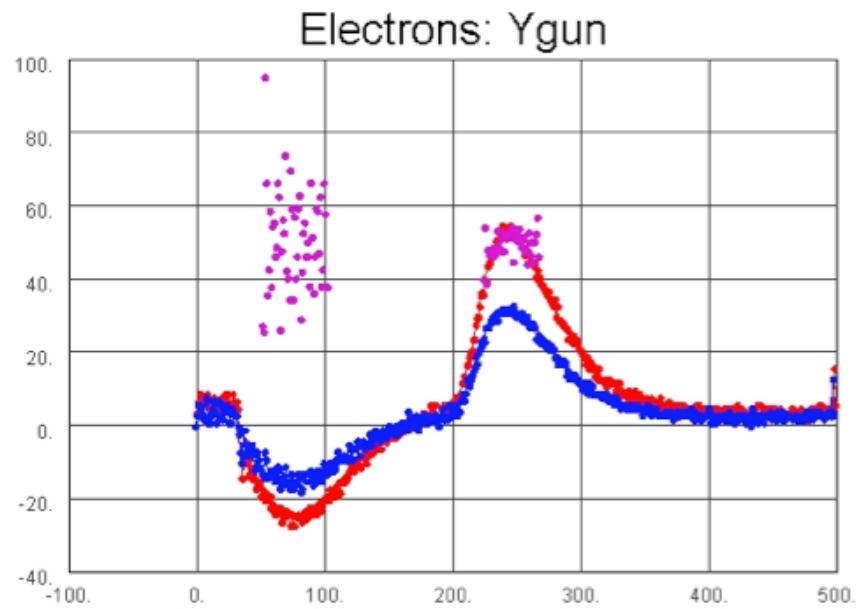
- Output voltage up to 6.5 kV
- Ability to act on individual bunches (bunch spacing 395 ns), highly configurable
- Low ripple flattop



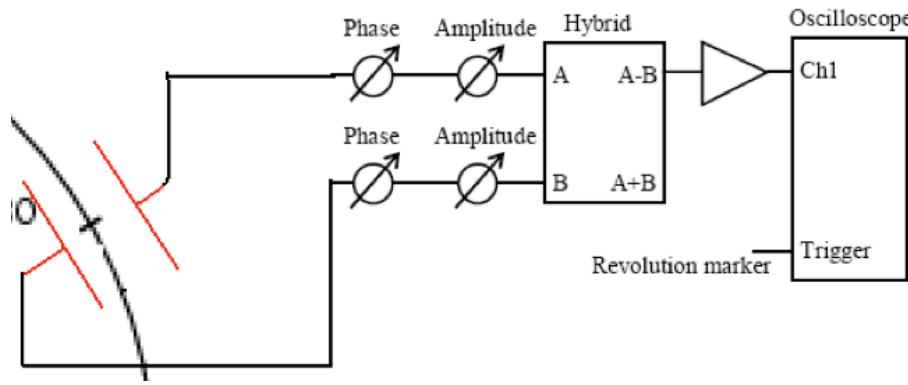
TEL Improvements: BPM Readout (A.Romanov)



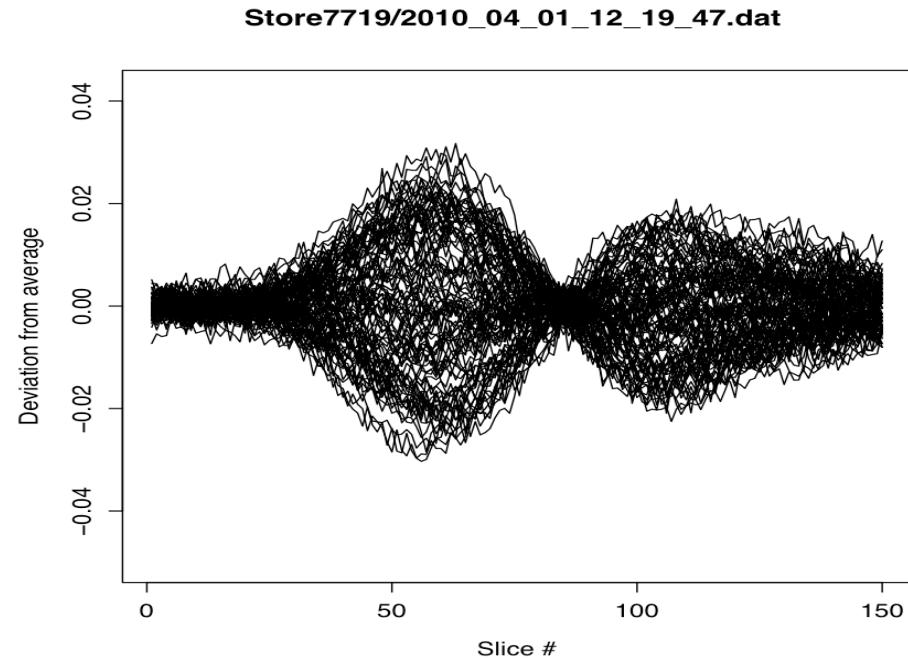
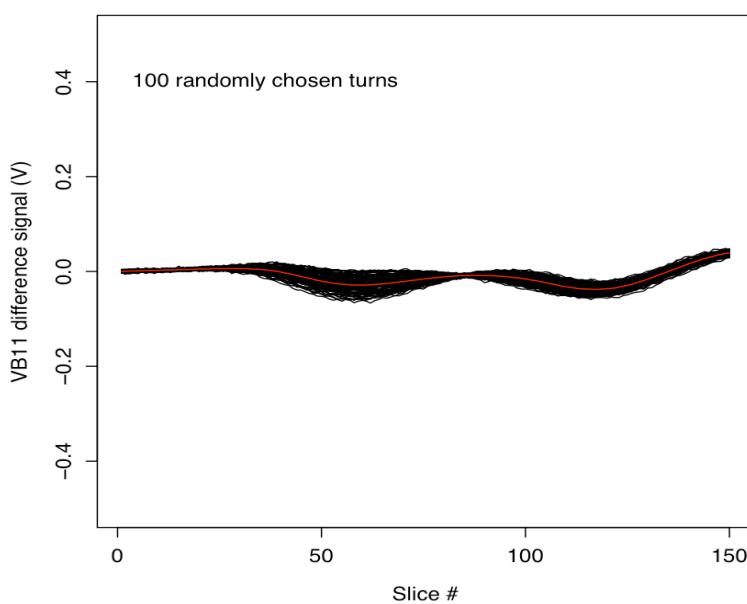
- Shorter e- pulse with new generator – closer calibrations and offsets for electrons and protons/pbars
- Old LabView program slow
- New Java program faster (response time ~20 s), uses simpler algorithm



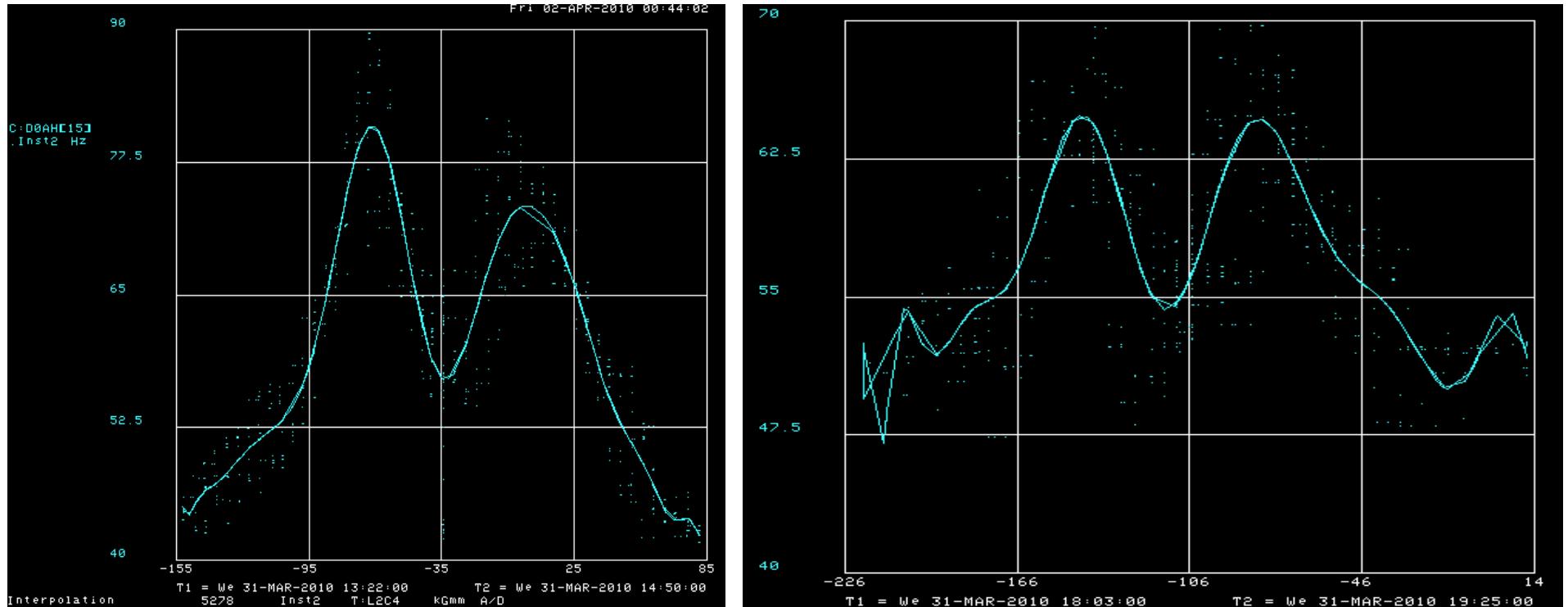
TEL Improvements: High Resolution Tevatron BPM



- Sample A-B signal from one bunch at 0.125ns/point for 57000 turns
- Subtract average
- FFT signal from selected slices



Recent Results: Alignment of e- and pbar beams (Store 7718)

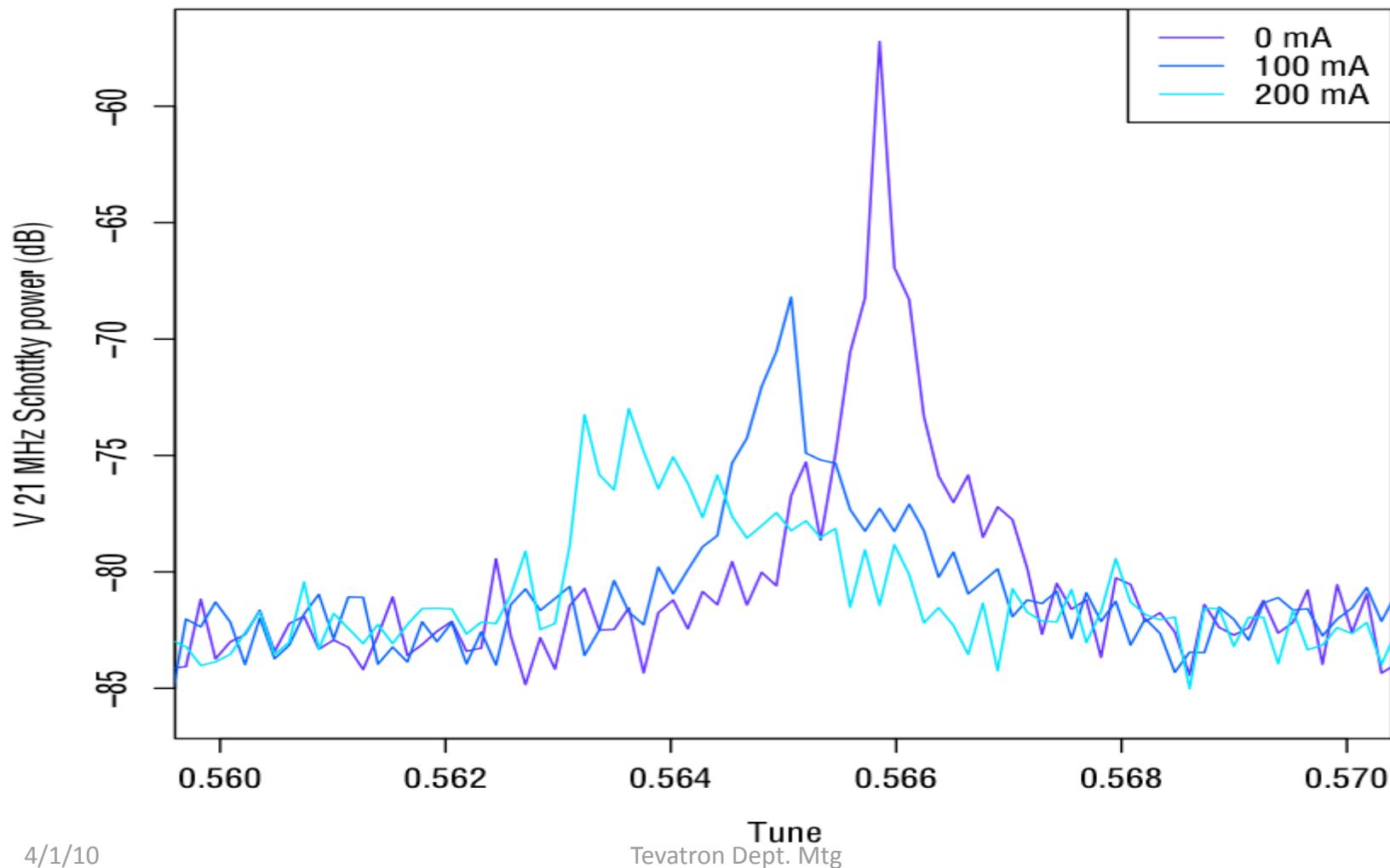


Horizontal scale is 2 mm /division

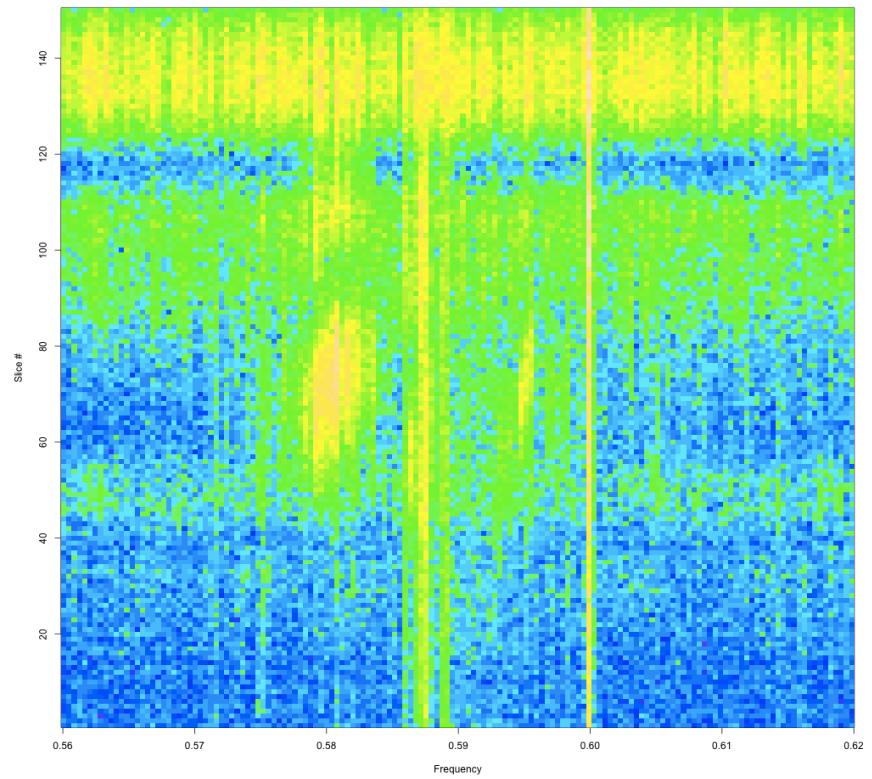
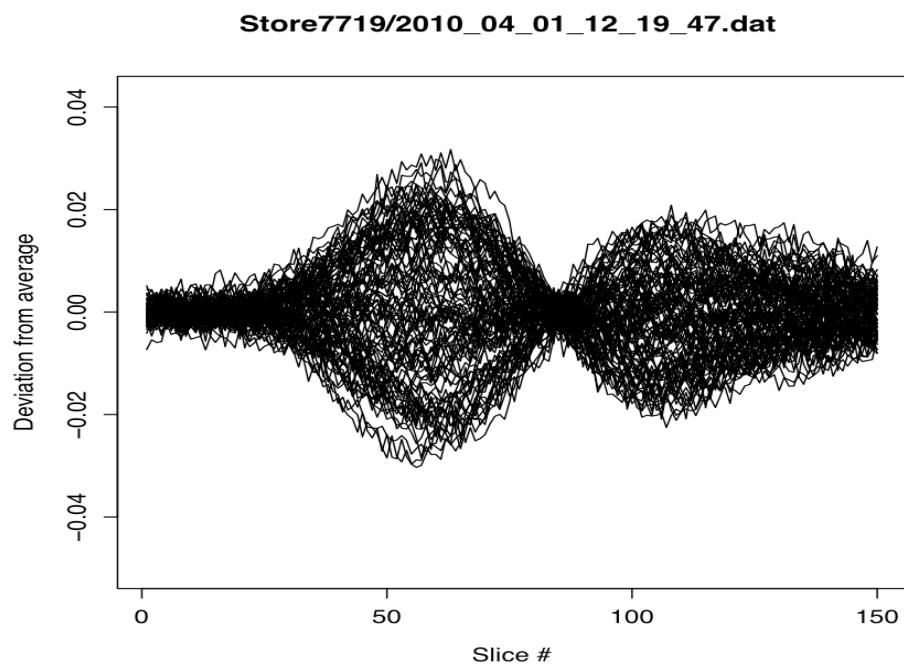
- Symmetry
- Good agreement with expected width in both planes

Recent Results: Tune Shift and Spread in Pbar-Only

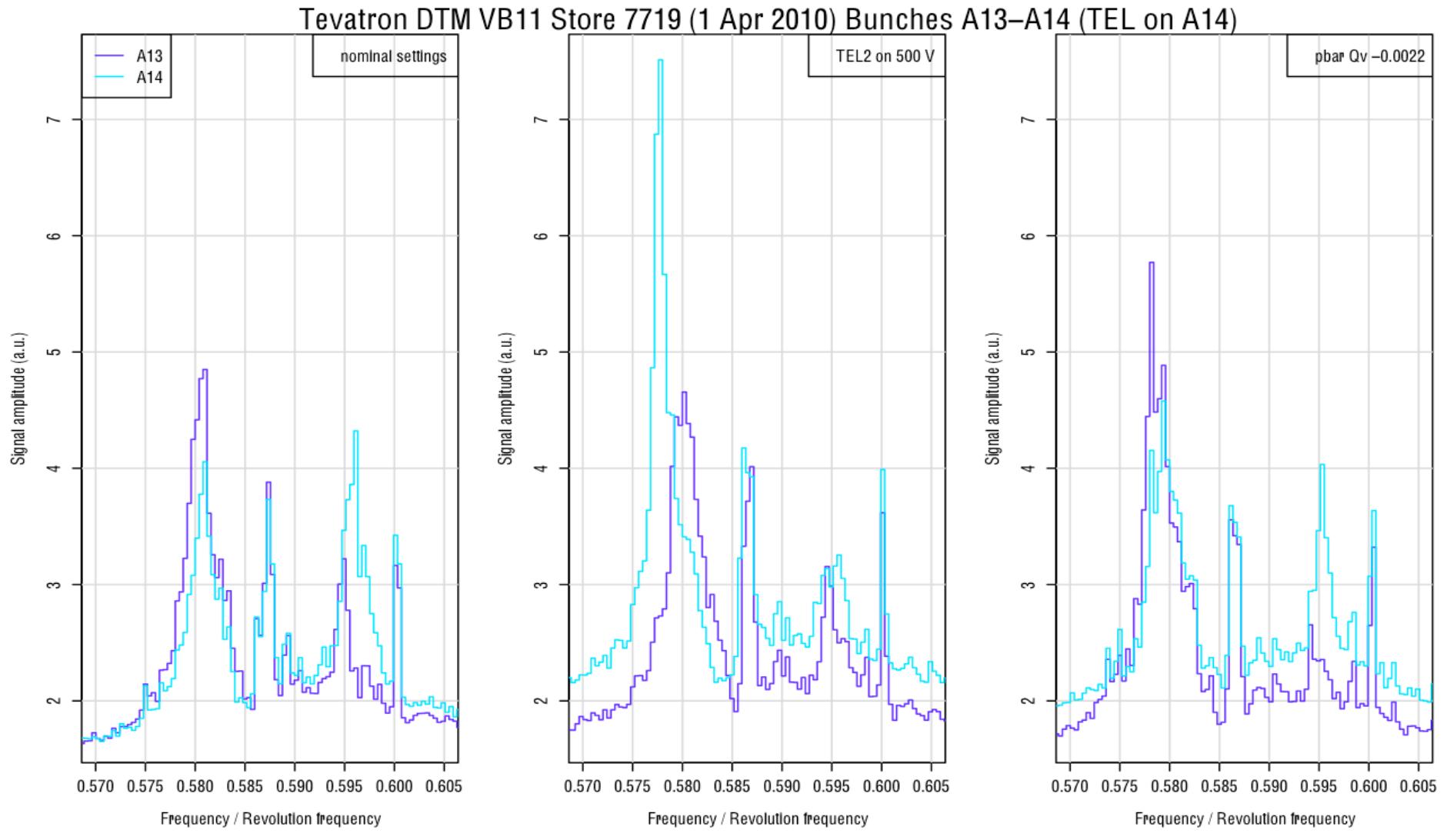
Pbar-only store 7720 – TEL on A1–A4



Recent Results: Coherent Tune Measurement in Store 7719



Recent Results: Coherent Tune Measurement in Store 7719



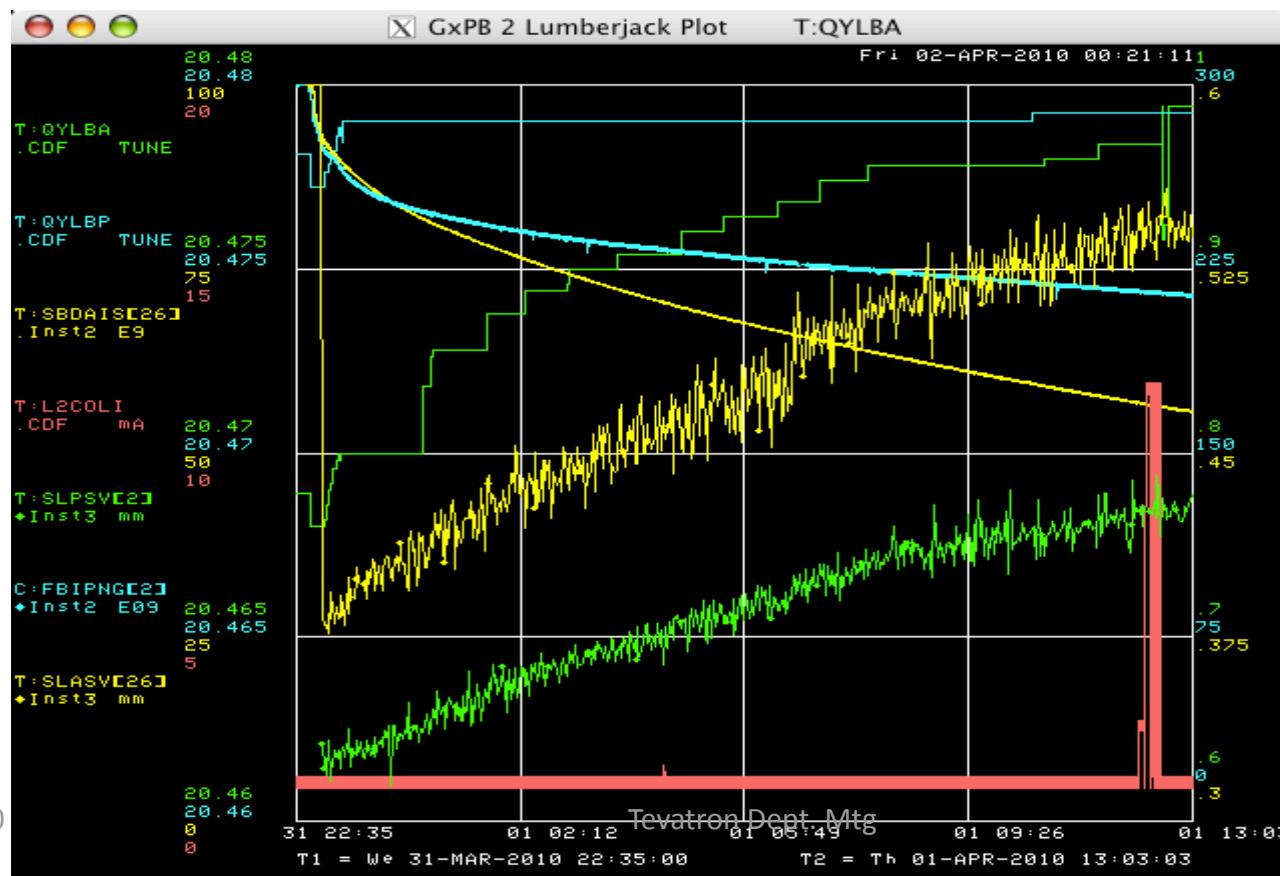
Beam Parameters in Store 7719

At the beginning of store

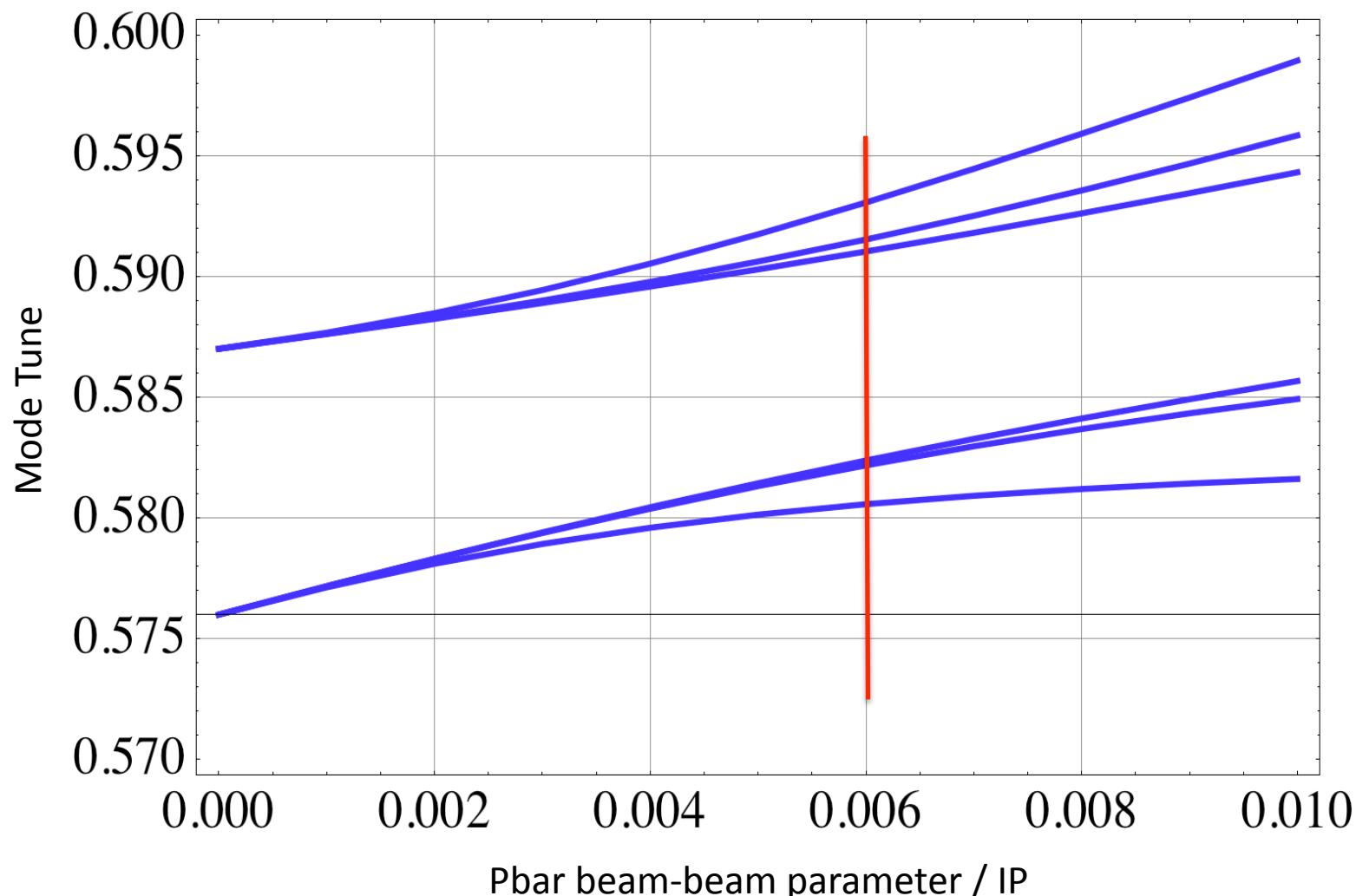
- $N_p = 2.7 \cdot 10^{11}$, $N_a = 0.9 \cdot 10^{11}$
- $\sigma_p = .6$ mm, $\sigma_a = .37$ mm (at synclight)
- $\xi_p = .017$, $\xi_a = .023$
- $Qv_p = 0.586$, $Qv_a = 0.566$

At the time of measurement

- $N_p = 2.2 \cdot 10^{11}$, $N_a = 0.5 \cdot 10^{11}$
- $\sigma_p = .78$ mm, $\sigma_a = .5$ mm (at synclight)
- $\xi_p = .006$, $\xi_a = .012$
- $Qv_p = 0.586 + 0.001 = 0.587$,
 $Qv_a = 0.566 + 0.01 = 0.576$



Interpretation of Modes in Store 7719



Coherent beam-beam modes for a system of 3x3 bunches colliding at two IPs.
Same modes should be seen in proton beam!

Summary of Results

- Demonstrated good alignment of e- and pbar beams
- No pbar life time degradation up to TEL current of 0.5A
- Observed tune shift and tune spread from TEL in a pbar only store
- Coherent modes observed in HEP stores are close to model prediction
- Observe coherent mode tune shift in pbar bunches interacting with TEL beam

What's Next?

- Work with data, explain observed tunes and tune shifts, study effects of imperfections
- Demonstrate head-on beam-beam compensation in special stores
 - 3 proton and 3 antiproton bunches (1,13,25) – only 4 LR collisions at large separation
 - Increase antiproton emittance to $14\text{-}16 \pi \text{ mm mrad}$ to enhance head-on beam-beam in antiprotons
 - Perform a tune scan with TEL on one of the antiproton bunches
 - Would only need 1-2 such stores, 1-2 hours each
 - Do not need high pbar intensity